Mapping rainwater management strategy

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Introduction

Integrated rainwater management is a recently developed holistic concept that abandons the differentiation between irrigated and rain fed agriculture (Rockström et al., 2003, 2010; Humphreys et al., 2008). It encompasses any bundle of practices that aims at increasing rainwater productivity or retention at landscape scale. It includes practices such as increasing soil water holding capacity, enhancing crop and livestock water productivity, improving efficiency of small scale irrigation, efficient use of ground water wells, diversion, or water harvesting (Johnston & McCartney 2010; Rockström et al. 2010; Brown & Hansen 2008; Hanjra & Gichuki 2008).

Whereas bio-physical suitability as well as water management practices are relatively well agreed on, there is a lack of understanding which practices needs to be bundled in order to optimize water retention or water productivity within the watershed at landscape scale. Furthermore, locations suitable for a bundle of practices, also referred to as a strategy, in terms of bio-physical, socio-economic and institutional aspects are yet unknown.

The objective of this paper is to present a methodology to identify suitable locations for various rainwater management strategies. The methodology is illustrated with one rainwater management strategy in the Blue Nile Basin in Ethiopia.

Definition of rainwater management strategy

In this paper, a rainwater management strategy at landscape scale is defined as a bundle of water management practices in a broad sense that cover the whole gradient of the landscape and maximizes water retention or water productivity within the landscape (micro-watershed or sub-basin). The bundle needs to be composed of (1) practices increasing water infiltration on the upper slope (for example reforestation), (2) practices increasing in-situ soil and water conservation in the midslope (for example terraces) and (3) practices that improve efficient use of surface and shallow water on the flatland (river diversion, wells). These practices can also be combined with grassland-specific practices (for example increasing grass quality) and heavily degraded land practices (e.g. gully rehabilitation).

Modeling approach

The modeling approach is illustrated with the strategy "orchard-terraces-river diversion" and is applied to the Ethiopian Blue Nile (Figure 1). In order to identify location where the strategy is most likely to succeed, a two-step approach is taken.

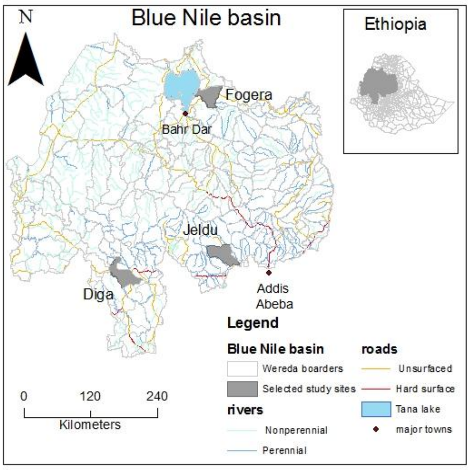

Figure 1 : The Blue Nile Basin in the Ethiopian Highlands

Step 1: mapping feasibility for single practices

In a first step, single rainwater management practices are selected and conditions of success identified and mapped out. Bio-physical conditions, namely rainfall, temperature, soil, slope and elevation are usually well understood, and therefore thresholds for suitability can be defined through a literature review, completed by expert knowledge. For each suitability condition, a binary map, indicating location where the conditions are met, is created, based on the existing geographic layers. These layers can then be combined with an equal weight overlay into a bio-physical suitability map. This map is by construction a binary map that indicates locations where all bio-physical conditions are met. Socio-economic / institutional conditions are often less well understood than the bio-physical ones and it is difficult to define credible thresholds. Instead of trying to define arbitrary thresholds, the socio-economic / institutional drivers can be seen as contributing to the adoption of a practice, the values of which need to be normalized to a variable between 0 and 1. The approach chosen in this paper is to use a small area estimation technique. It firstly assesses adoption of a given practice based on a household survey (explaining which household is likely to adopt the practice). It is based on a probit estimation that contains identified variables for which geographical layers exist. The coefficients of the probit estimation are then used to extrapolate the adoption for the whole area. Values of the resulting maps range between 0 and 1 and can be interpreted as willingness to adopt, and is therefore referred to as willingness of adoption layer (Figure 2).

Finally, the bio-physical suitability layer and the willingness of adoption layer can be aggregated with equal weight, into a single practice feasibility layer (Figure 3). This layer suggests not only locations where a practice is suitable but also the intensity of adoption given the socio-economic and institutional context.

Step 2: Up-scaling single feasibility maps into RMS at landscape scale

Step 2 aggregates the single rainwater management practice maps into a rainwater management strategy at the landscape scale by overlaying the three feasibility maps with a landscape delineation layer, in this case the FAO 6th level watershed.

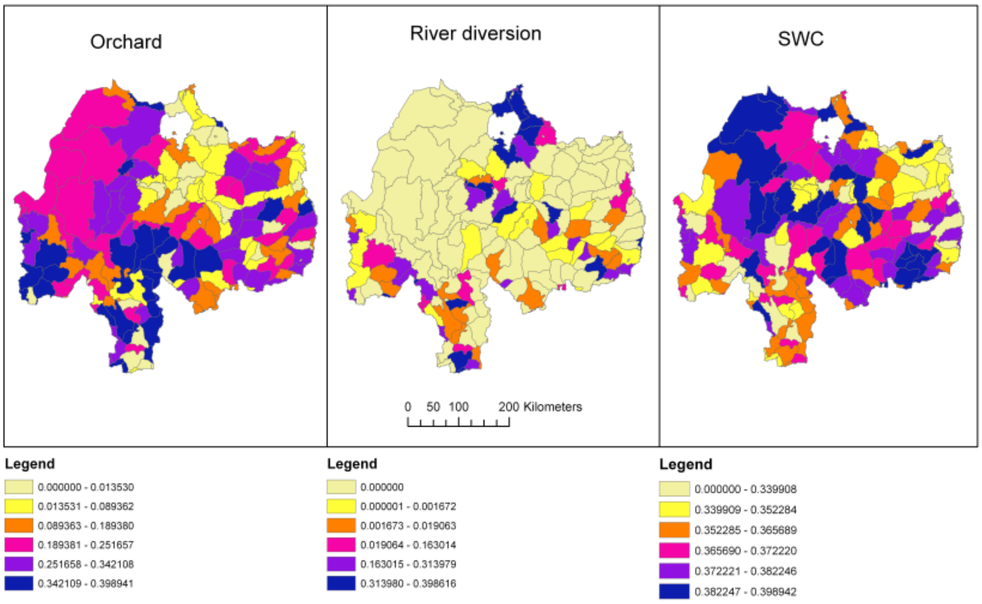

Figure 2 : willingness of adoption map for orchards, river diversion and SWC

Zonal statistics allows computing any more detailed statistics from the geographic overlay in each landscape (Figure 4): the total suitable area for each practice, the average adoption rate on suitable area for each practice, the average number of potential adopters (computed by multiplying adoption rate and population density).

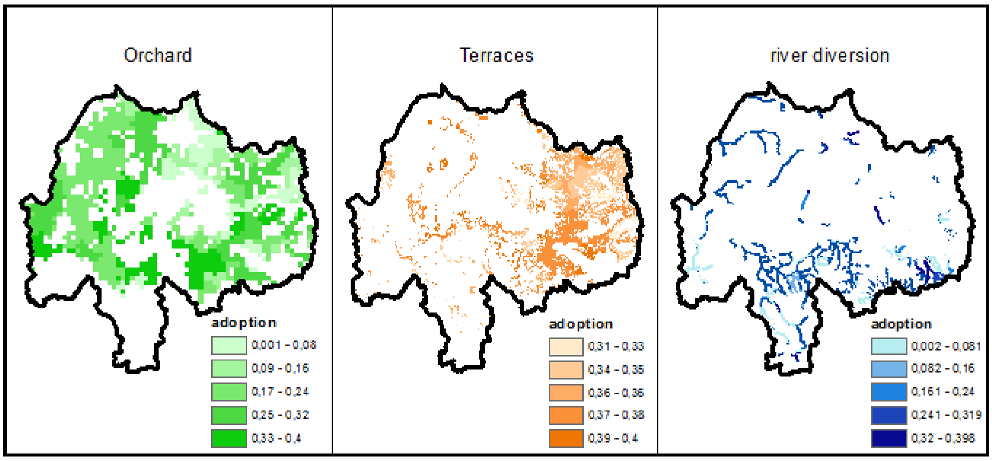

Figure 3 : feasibility map with the willingness of adoption

Discussion: Using the tool

These maps show to what extend contexts are different in the watersheds; therefore what has worked in one location might not work in another one. These maps are a starting point for a dialogue with communities to improve water management. Community involvement is crucial for three main reasons. Firstly the uncertainty linked to the maps: it is a way to validate the map based on local knowledge. Secondly, some strategies might not be incentive-compatible: one farmer might not adopt a practice because he would encounter a short term loss, which is the case with the orchard for example. Involving communities in a participative way, will lead

to find innovative benefit-sharing mechanisms from which the community as a whole can benefit. Thirdly, some strategies might not be implemented, because the area is missing a crucial element that could not be mapped and therefore not included in the modeling approach. These elements, like a missing access to a specific input market or lack of knowledge, are beyond farmers' decision making and generally require some intervention from other stakeholders, such as governments or NGOs. Involving the community will allow to identify these necessary interventions.

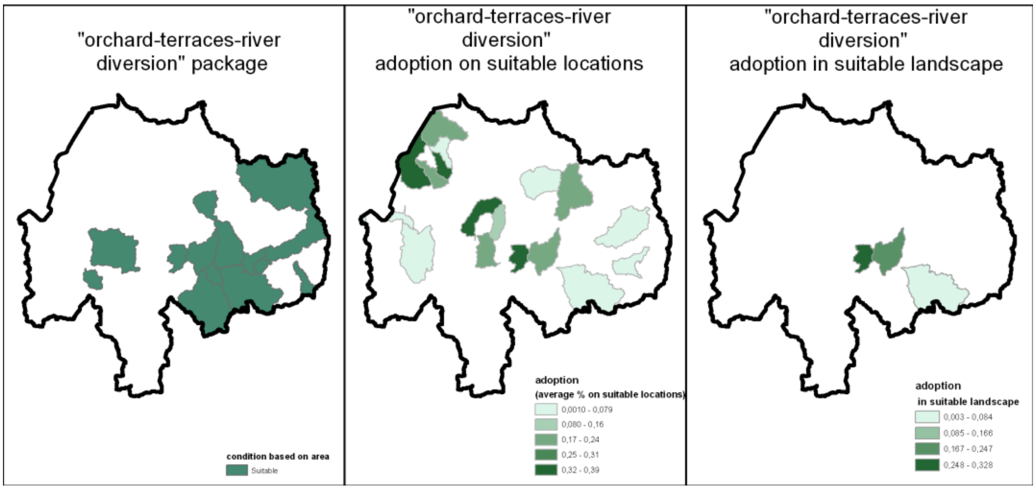

Figure 4 : left: map of suitable landscapes for the orchard-terrace-river, middle: map of adoption on suitable locations right: map combing the two.

Conclusion

The concept of integrated water management suggests that water management practices should be taken in a broad way, including practices linked to crop, livestock and trees. In addition, practices should be bundled into strategies in order to benefit from synergies at landscape scale. This paper presents an approach that allows to map these strategies taking not only bio-physical, but also socio-economic characteristics into account. The resulting maps are a starting point for NGOs and policy makers to develop context-specific rainwater management strategies with involved communities.

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